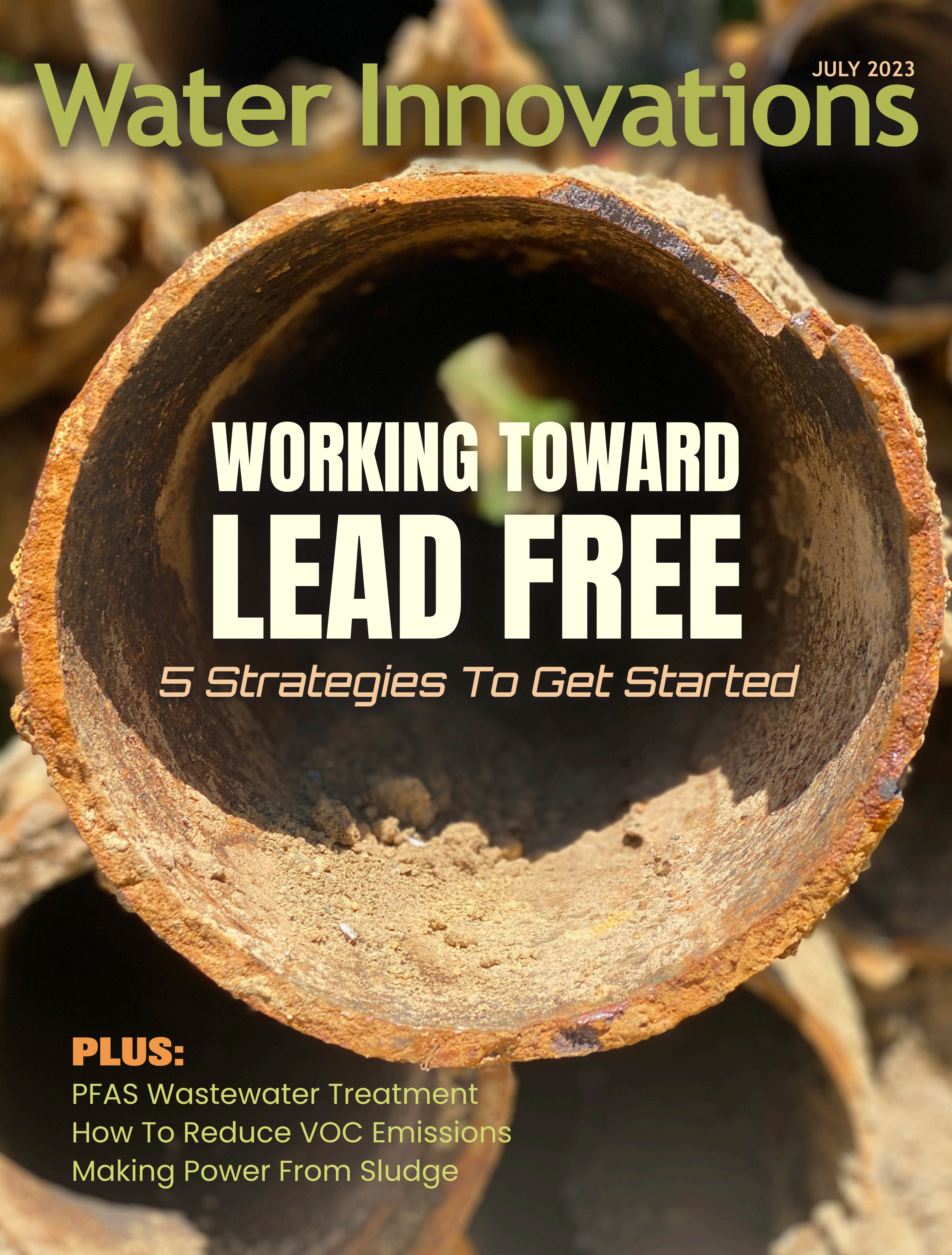
JULY 2023

Water Innovations



WORKING TOWARD LEAD FREE

5 Strategies To Get Started

PLUS:

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How To Reduce VOC Emissions

Making Power From Sludge

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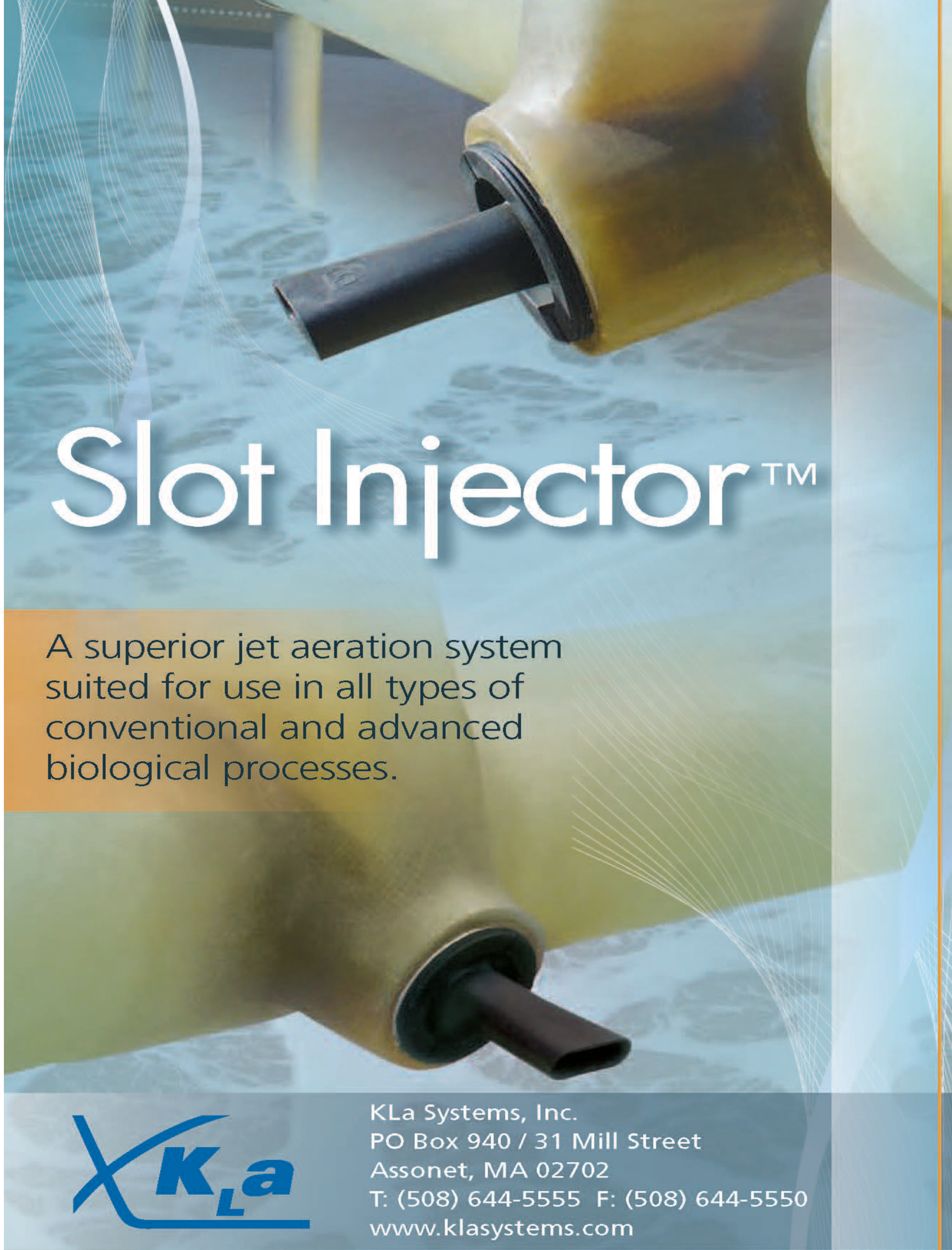

FROM THE EDITOR

By Kevin Westerling
Chief Editor, editor@wateronline.com

Water Pros Remain Optimistic Despite Mounting Challenges

As they have for each of the last 20 years, the American Water Works Association (AWWA) published its *State of the Water Industry Report* recently, revealing the current concerns of drinking water, wastewater, and stormwater professionals in North America. The annual survey typically reveals plenty of year-over-year consistency, but this moment feels different: Highly problematic and ubiquitous per- and polyfluoroalkyl substances (PFAS) and lead contamination have become top priorities from a water quality standpoint, while volume concerns — scarcity and flooding — remind us of the existential threat that climate change poses.

And yet, the number-one concern from those surveyed was none of the above. Furthermore, the optimism level among respondents ticked up to a score of 5.0 (4.97 in 2022) on a scale of 1 to 7, signaling strong confidence in the industry's ability to fulfill its overall mission — safeguarding public health, supporting and strengthening communities, and protecting the environment — both now and into the near future, as the score is a composite of their current and five-year outlook. Said AWWA CEO David LaFrance:

"AWWA members always amaze me. It seems like the harder the challenges get, the more confident and optimistic our members become. It's clear there are some significant hurdles in front of us … but water professionals never blink. They simply find ways to solve the problems in front of them and keep providing the world's most vital resource to their communities."

There were more surprises to be had in the report, which can be downloaded here. But perhaps, considering the resoluteness described by Mr. LaFrance, there should be less shock and more awe about the level of grit displayed by water professionals.

Top 10 Challenges: 2023 vs. 2022

- Despite the high profile and elevated importance of recent issues — with proposed federal PFAS Maximum Contaminant Levels (MCLs) having been published and the compliance deadline for Lead and Copper Rule Revisions upcoming in October 2024 — survey respondents continued to name ***rehabilitation & replacement (R&R) of aging water infrastructure*** as their top challenge, going on 10-plus consecutive years now.
- ***Long-term drinking water supply and availability*** supplanted ***financing for capital improvements*** as the second-biggest challenge, with the latter dropping into the third spot.
- ***Public understanding of the value of water resources*** catapulted into the fourth position, up from eighth in 2022.
- ***Watershed/source water protection*** rounded out the top five after coming in seventh last year.
- ***Compliance with current regulations*** snuck into the 10th spot and was this year's only new entrant into the top 10 compared to 2022.
- The remainder of the top 10 (followed by 2022 position) included:
  - #6 – Aging workforce/anticipated retirements (4)
  - #7 – Public understanding of the value of water systems and services (5)
  - #8 – Emergency preparedness (6)
  - #9 – Groundwater management and overuse (9)

Survey Says! Percentage Points Of Interest (figures rounded)

- 20% are extremely concerned about their ability to comply with PFAS mandates.
- 15% are extremely concerned about compliance with regulations related to lead and copper.
- 38% indicated their capital improvement plans included lead service line replacements.
- 88% have fully implemented or are in the process of preparing emergency response plans.
- 60% have implemented or are considering implementing a climate action plan.
- 32% have a fully developed drought management or water shortage contingency plan.
- 31% have fully implemented a water conservation program.
- 46% reported plans to update or install meter-reading systems.
- 78% expect to increase water rates in the coming year.
- 100% benefit from reading *Water Online* and *Water Innovations* to help meet their goals.

Okay, that last one is not from the AWWA report, but I believe it — because, optimism!

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PFAS IN WASTEWATER: Promising Management And Treatment Strategies

A review of emerging PFAS treatment technologies, including case studies, to help operators evaluate options for mitigation

By Jay R. Surti, PE, with Charles Winslow, PE, and Beth Landale, PE

The presence of "forever chemicals" in wastewater is a significant impediment for water and resource recovery facilities (WRRFs) to recover resources (water, energy, nutrients) and serve as anchors for the circular economy and a decarbonized future. These chemicals, formally named per- and polyfluoroalkyl substances (PFAS), enter WRRFs directly through sewage and industrial effluent, including landfill leachate and septage. Sewage and industrial effluent often contain PFAS because of widespread use of PFAS-containing materials by industry and consumers. PFAS therefore end up in both the liquid and solids streams of treated wastewater, and from there to landfills, groundwater, receiving waterbodies, and farmland through biosolids land application programs.

PFAS Health Effects And Characteristics

Since the first manufactured chemical in the PFAS family was invented in 1947, these compounds have proliferated, and there are now more than 5,000 species. The widespread use over the past several decades has led to the omnipresence of PFAS in the environment through manufacturing waste streams and disposal of PFAS-containing materials. PFAS have gained national attention because they are harmful to human health, they persist in the environment, and they are challenging to treat. While studies are ongoing and there is still much to learn, peer-reviewed studies indicate that at certain exposure levels, some chemicals in the PFAS family may lead to reproductive effects in pregnant women, developmental delays in children, increased cancer risks, lower immune response, hormone interference, increased cholesterol levels, and increased risk of obesity.

An understanding of PFAS chemistry is essential for understanding the refractory (resistant) and persistent nature of PFAS chemicals and why they are difficult to treat. Terminal perfluoroalkyl acids (PFAAs) — those such as PFOA and PFOS, which are the end degradation products of larger PFAS molecules — are extremely stable both thermally and chemically, and they resist degradation and oxidation. Their thermal stability is primarily attributable to the strength of the carbon-fluorine (C-F) bond. There is a growing interest in commercially viable thermal treatment technologies such as incineration, gasification, and pyrolysis for PFAS destruction because of the high energy required to break the C-F bond. Other technologies gaining attention for PFAS destruction include advanced oxidation processes, photocatalysis, UV irradiation, electron beam, and plasma-based treatment. However, these technologies are still in the early research and development phase. As PFAS contamination limits resource recovery and restrictive regulations increase, solutions to the PFAS challenge become ever more urgently needed.

Evaluation of full-scale WRRFs has indicated that conventional primary (sedimentation and clarification) and secondary (biological) treatment processes can result in changes in PFAS

concentrations and classes such as increased PFAA concentrations in effluent compared with concentrations in influent, presumably from degradation of precursor PFAS. Limited research has been performed to understand the fate of PFAS during commercially viable solids stabilization processes that are typically employed to produce safe and high-quality biosolids by reducing pathogens and the potential to attract vectors.

PFAS Management And Treatment Strategies

Technologies and solutions are being implemented for reducing WRRF risks by treating PFAS at the source, or capturing or treating them in wastewater and biosolids matrices. PFAS management and treatment strategies can be broadly classified as follows:

1. Source control to reduce PFAS load to WRRFs (discussed below)
2. Separation and likely destruction of PFAS during wastewater treatment (illustrated with two case studies).

Managing PFAS Before They Enter WRRFs

WRRFs are passive receivers of PFAS chemicals. Source control is the most efficient way to reduce PFAS loads in wastewater influent. Existing industrial pretreatment programs (IPPs) for managing chemicals in wastewater from industrial facilities may be useful for PFAS source control. However, although source control can reduce PFAS concerns for utilities, it may increase operational challenges and costs for upstream industrial contributors.

Several major WRRFs significantly reduced PFOS discharges using point source treatment under Michigan's PFAS IPP initiative. Seven used granular activated carbon (GAC), with a few adding treatments such as columns with resins and changing the water supply. Table 1 compares effluent PFOS levels for several of these facilities after they implemented source control, with a goal of reaching Michigan's water quality standard (WQS) of 12 ppt for non-potable surface water sources. Several utilities reduced levels below this WQS.

Treating PFAS: Containing Groundwater And Biosolids

Case Study: Biosolids Pyrolysis — Ephrata, PA

Introduction

With concerns about the presence of PFAS in biosolids and their potential impact on biosolids beneficial use programs across North America, there is an urgent need to develop mitigation and treatment solutions for PFAS in biosolids. The Ephrata Borough Authority owns and operates two municipal wastewater treatment plants (WWTPs) in Lancaster County, Pennsylvania. The design-rated capacity of WWTP #1 is 3.8 MGD. With equipment at WWTP #1 aging, rising costs of landfill disposal, and the likelihood of new PFAS regulations in the future, the Authority sought to determine an optimal solution to address biosolids operational and disposal challenges, reduce reliance on third-party contractors, and enhance resilience and sustainability.

The Authority decided to implement biosolids pyrolysis because lifecycle costs would be lower and the construction sequence and schedule would be more favorable than upgrading the existing anaerobic digestion process. In addition, existing digesters could be used for sludge storage and to reduce high-strength nutrient loads being returned to the liquid treatment process. The BioforceTech® biodrying and pyrolysis process was selected for the project. Preliminary analytical testing conducted by the technology provider has demonstrated non-detect levels of 38 PFAS compounds in biochar produced through pyrolysis treatment of anaerobically digested biosolids. GHD provided the design, permitting, and construction-phase services for the new pyrolysis system. Figure 1 is a process flow diagram of the upgraded WWTP #1 solids treatment process after implementation of the biosolids pyrolysis process.

Biosolids Pyrolysis And PFAS

Recently there has been renewed interest in implementing thermal oxidation processes to allow the beneficial use of wastewater

Table 1: Michigan IPP Initiative To Treat PFAS At The Source

Municipal WRRF	PFOS in effluent (ppt)	PFOS reduction in effluent (from highest)	Action(s) taken to reduce PFOS
Bronson, Wixom, Lapeer, Ionia, and GLWA (Detroit)	12, 17,[a] <18,[a] 25,[a] 37[a], respectively	97%, 99%, 99%, 95%, 23%, respectively	GAC treatment at source; all had one source except GLWA, which had nine
Kalamazoo	5	88%	GAC treatment at source and change of water supply
Howell	4	97%	GAC and resin treatment at source
Port Huron	15[a]	99%	Elimination of PFOS source
K I Sawyer	13[a]	95%	Elimination of leaking AFFF[b] and some cleaning

Source: Michigan IPP Initiative, Identified Industrial Sources of PFOS to Municipal Wastewater Treatment Plants, Aug. 2020
a. Greater than Michigan's Water Quality Standard of 12 ppt.
b. AFFF = aqueous film forming foam

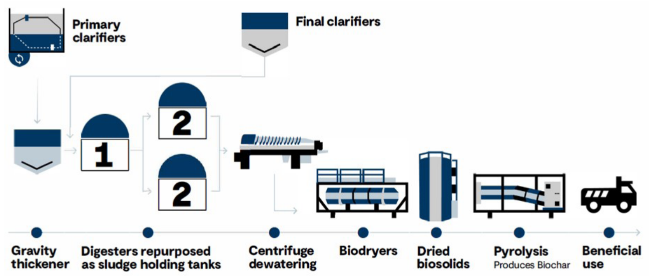

Figure 1. New biodrying + pyrolysis system at Ephrata Borough Authority's WWTP #1

biosolids while achieving significant weight and volume reduction. Pyrolysis is a nonbiological thermochemical process in which volatile organic compounds and some carbonaceous materials in the feedstock are converted into a combustible syngas (also known as synthetic gas, synthesis gas, or producer gas) in a high-temperature, oxygen-free environment, leaving behind a small amount of biochar. Char consists of both inert materials (ash) and carbonaceous materials not volatilized into a gas phase.

Pyrolysis — literally meaning "to break with fire" — occurs after the majority of the water has been evaporated from biosolids. During pyrolysis, the combination of high temperatures (600°F to 1,200°F) and an oxygen-starved environment causes volatilization of organics. These include low molecular weight gases as well as tars and oils. Figure 2 is a process flow diagram of a close-coupled biosolids pyrolysis system utilizing a municipal wastewater solids feedstock.

As of this writing, there are currently no U.S. EPA-mandated regulations for PFAS compounds in municipal wastewater effluent discharges or wastewater biosolids. However, concern about the occurrences of PFAS compounds in drinking water and groundwater could likely lead to future regulation and monitoring of PFAS in wastewater effluent discharges and wastewater biosolids. Thermal technologies such as pyrolysis have been shown to be capable of producing biochar that does not contain detectable levels of PFAS. Active research is underway to assess the efficacy and pathway of PFAS destruction in a close-coupled biosolids pyrolysis system.

Case Study: PFAS Treatability Studies For A Site In Michigan

Introduction

At a former Michigan industrial site, PFOA and PFOS were found in groundwater, although only PFOS was present above the Michigan surface water WQS. In 2019, efforts began to develop a cost-effective plan to remove them and other contaminants (iron, phosphorus, and oil and grease) to meet standards for discharge under a National Pollutant Discharge Elimination System permit.

GHD developed a conceptual design for a treatment sequence and conducted bench-scale studies on the efficacy of (1) pretreatment, (2) two adsorption technologies shown to be effective, and (3) an emerging destructive technology. The short-term goal was

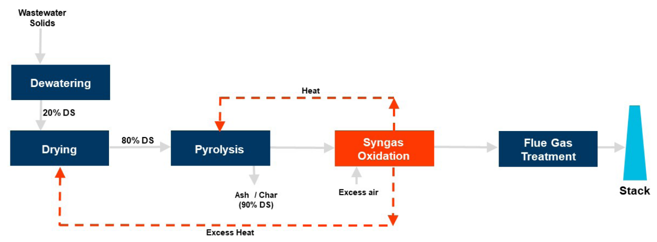

Figure 2. Process flow for a close-coupled biosolids pyrolysis system

to find the most cost-effective conventional treatment for the PFAS compounds currently regulated, PFOA and PFOS. Longer term, the goal was to begin investigating emerging technologies that could destroy the PFAS captured in treatment media, so the financial costs of disposal and the environmental costs of continued presence could be avoided. In GHD's fully equipped treatability laboratory in Niagara Falls, New York, scientists and engineers tested treatments for PFOA and PFOS, as well as 10 other PFAS compounds on Michigan's Environment, Great Lakes and Energy (EGLE) analyte list but not yet regulated (12 additional PFAS compounds are on the list but were not found in the site's groundwater).

Conceptual Design Of The Treatment Train

GHD designed a treatment sequence that included pretreatment with ferric chloride to coagulate the iron and other contaminants in the groundwater, which would otherwise reduce the lifecycle of adsorptive media, and to precondition the groundwater for PFAS removal through adsorption (GAC or ion exchange [IX]). The coagulated solids would be removed through settling. Bag filters would then remove non-settleable and colloidal particles, and the pretreated stream would be conveyed through adsorption vessels for removal of PFAS (Figure 3).

Treatability Studies

Pretreatment, GAC, and IX were tested in the lab, as well as several other treatment options not discussed herein.

Pretreatment: Consider the entire unique stream.
No two contaminated liquid streams are the same. Whether

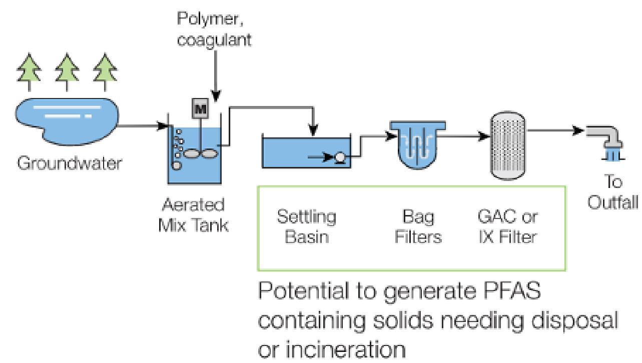

Figure 3: PFAS-contaminated groundwater treatment steps

With concerns about the presence of PFAS in biosolids and their potential impact on biosolids beneficial use programs across North America, there is an urgent need to develop mitigation and treatment solutions for PFAS in biosolids.

planning for groundwater or wastewater treatment, the effect of all contaminants on the treatment process and efficiency must be considered. The results of the pretreatment study highlighted the need to develop appropriate pretreatment to remove co-contaminants that could impede or reduce the efficiency of PFAS treatment. The effects of other contaminants on the lifecycle of the treatment media, and thereby the cost-effectiveness of the treatment plan, are also important to consider. The bench-scale studies identified effective processes and ferric chloride (coagulant) concentrations needed to remove iron and other contaminants to pretreat this groundwater stream.

Adsorption using GAC: Proven approach #1
Adsorption kinetics differ, depending on the specific PFAS compound and its affinity for carbon adsorption. GAC from various manufacturers can also work better for some streams than for others. GAC from two manufacturers was tested at bench scale for its ability to adsorb the PFAS compounds from pretreated and non-pretreated influent. Media from both manufacturers were effective in removing PFOS (the only regulated PFAS above WQS) to below the WQS. In addition, both types removed phosphorus to below its WQS. And in both, shorter-chain PFAS broke through the adsorption columns first. Although the primary focus of the treatability studies was to assess the removal efficiency of PFOA and PFOS, it was concluded that the affinity of different PFAS compounds for adsorption can vary. The design of the adsorption system would need to be flexible such that it could be modified to achieve removal of other PFAS compounds if subjected to regulations in the future.

Adsorption using IX: Proven approach #2
PFOS did not break through at all on the IX column, and the IX resin achieved higher throughput per unit mass of media than did the GAC. As with the GAC, shorter chains broke through more quickly than longer chains in the IX column.

GAC and IX compared.
Both GAC and IX removed PFOS below the WQS, but both result in residuals (adsorption media) containing PFAS that must be destroyed or managed carefully. A lifecycle evaluation is required to determine the lifecycle costs of GAC and IX adsorption systems to allow comparison. GAC was chosen as the adsorption medium for the temporary treatment system because of its easy availability and the client's prior experience. Lessons learned during the temporary treatment system include the high fouling potential of GAC media because of the presence of iron.

Conclusion

The information discussed herein will help utility owners, operators, and engineers increase understanding of the growing concerns about PFAS for the wastewater industry, the evolving regulatory environment, and promising management and treatment strategies to address PFAS-related challenges. PFAS risk management and treatment technologies are evolving in parallel to proposed federal and state regulatory guidance criteria. Each technology has pros and cons related to pretreatment requirements, individual PFAS removal rates, and ease of implementation at the full-scale level.

Destructive PFAS treatment technologies to mitigate long-term risks and liabilities for end users are emerging as practical solutions and reaching commercial scale. The case studies discussed herein suggest that destructive technologies exist but require careful evaluation to fully understand byproducts formed during the process, transformation pathways, and associated capital and lifecycle costs.

In parallel with these evaluations, we recommend utilities act now to evaluate operational risks and develop mitigation plans to address the regulatory uncertainty related to PFAS. This could include actions such as:

- Characterization and fate and transport of PFAS throughout operations, including in water, wastewater, biosolids, and spent media.
- Evaluation of existing treatment systems and their ability to remove or treat PFAS.
- Treatability trials to develop PFAS removal (separation) and destruction solutions.
- Adaptive planning in light of regulatory uncertainty.
- Evaluation of alternative approaches for managing biosolids produced during wastewater treatment, especially if they will be applied to land. ■

About The Author

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5 STRATEGIES TO MOVE TOWARD A LEAD-FREE RURAL WATER SYSTEM

Lead service lines are poisoning communities, many of which are already disadvantaged, making it a national emergency that utilities must address with haste. These tips guide the way.

By Michael Griffiths

"Getting the lead out" is becoming a very slow-moving process when it comes to replacing lead-based water service lines. However, one thing's certain: Historical lead pipes aren't doing residents of small American communities any favors. That's why many utilities and cooperatives are beginning to take steps toward finally ridding their water systems of lead.

Just how large a problem is lead contamination in drinking water across the nation? According to research from the American Bar Association, an estimated 21 million people were exposed to drinking water that held unacceptable amounts of contaminants in 2015 alone — lead was one of those contaminants. Although it would be appealing to assume that the figure is much lower now, not much has changed since then.

There are multiple reasons why many households in small towns haven't upgraded from aging lead pipes. Most are financial. For instance, homeowners don't want to have to pay more every month, either to pay for replacements themselves, or to cover "passed on" fees from their water utility providers.

Remember that the average cost of an individual household lead service line replacement can hover just under $5,000. That's not exactly pocket change to rural residents, many of whom may struggle with financial insecurity.

Utilities don't want to charge their customers more, either. The last thing a utility wants is to set itself up for the negative press of a significant rate hike. This leaves both parties in tacit agreement to ignore the lead lines.

Another barrier to replacing water lines is that the water itself might taste fine, even though it's contaminated. Many residents are surprised when they find out that their drinking water exceeds the U.S. EPA's lead limit of 15 parts per billion. Even then, they may just install water filters as a temporary measure instead of addressing the issue.

Fighting For Water Quality ... and Equality

Despite the obstacles inherent in replacing water lines en masse, communities and the people who live and work in those communities deserve to have clean, potable water. Replacing lines isn't just a "nice to have" project. It's a necessary — but fortunately, a one-time — solution that will bring major health benefits to rural Americans.

Many studies have found fault with the EPA's ruling on "acceptable" lead levels in drinking water, especially for young kids. Poor-quality drinking water that contains lead has been linked to cognitive issues in children.

Is it any wonder that between 2020 and 2021, state legislatures enacted no fewer than 500 bills related to lead in drinking water, mostly focused on children and lead poisoning? The point is that any lead exposure could be bad for the youngest, most vulnerable populations.

Customers need to be educated about what their pipes are constructed of and how those materials can affect their water quality.

So, how can utilities and cooperatives begin moving the needle? Below are five good starting points:

1. Identify how broad-based the problem is.

It's hard to make any progress without knowing just how big the problem of lead service lines is in any given community. As other communities have done, utilities can create maps of their service line networks. These maps can help identify concentrations of lead pipelines.

Knowing the extent of the issue makes it much easier to tackle. Plus, digital maps can help let consumers and businesses know whether they might be at risk of drinking lead-contaminated water. In Cincinnati, the city's online and interactive database serves as a single source of lead service line truth for consumers.

2. Inform customers about potential lead pipeline contamination.

The average customer doesn't think about lead contamination when turning on the tap. Customers need to be educated about what their pipes are constructed of and how those materials can affect their water quality. The more they know, the more likely they'll want their utilities or cooperatives to help them solve the problem.

Customer education can take many forms, including regularly updated digital portals. For instance, a utility might want to create blog posts about water regulations and standards. A topic, such as a quick overview of the "Revised Lead and Copper Rule" from the EPA, can become the springboard for many pieces of informative content.

3. See how other communities have replaced their lead pipes effectively.

Some communities, utilities, and cooperatives have been very successful in upgrading their water systems. Consequently, other communities should take notice. Building a playbook based on a city or town that has already undertaken the effort can be simpler than starting from scratch.

Some considerations to look for in other communities include how long projects took and how the projects were paid for. Again, every area will have unique needs, but following in other communities' footsteps makes sense.

4. Look for funding sources.

As mentioned above, any kind of pipe replacement is costly. That's why it's important to stay on the leading edge of any funding streams available to cooperatives, utilities, towns, etc. For instance, the EPA has some excellent resources and links to various types of water project grants and loans, such as the Drinking Water State Revolving Loan Fund.

Not all will apply to every community or organization, of course. Nevertheless, some may be able to cover all or a part of replacing lead water lines, while other funds might help cover the cost of educating customers with seminars, workshops, or marketing materials. Cobbling together various money streams can be more pragmatic than hoping to find one single source to pay for everything.

5. Build a framework for replacing all the lead service lines.

With the right information and well-educated customers, utilities and cooperatives can begin building timelines to replace all the lead service lines. This won't happen overnight. Even incremental improvements can make a huge difference — and they spread out the costs.

In time, the overarching goal can be a lead-free water system. Though some customers might not like absorbing minimal costs along the way, most will appreciate not having to worry about the quality of the water they and their families are drinking.

Lead pipes become ever more hazardous over time. Waiting is riskier than doing something now for the good of rural residents and visitors. ■

References

1. https://www.americanbar.org/groups/crsj/publications/human_rights_magazine_home/vol--44--no-2--housing/rural-america-s-drinking-water-crisis/
2. https://www.epa.gov/sites/default/files/2019-10/documents/strategies_to_achieve_full_lead_service_line_replacement_10_09_19.pdf
3. https://www.epa.gov/dwreginfo/lead-and-copper-rule
4. https://www.science.org/doi/10.1126/sciadv.abn5164
5. https://www.ncsl.org/environment-and-natural-resources/state-and-federal-efforts-to-address-lead-in-drinking-water#anchor16079
6. https://geo.dcwater.com/Lead/
7. https://gcww.maps.arcgis.com/apps/webappviewer/index.html?id=0a170c268c694e46a8a4e394630df0bd
8. https://www.epa.gov/ground-water-and-drinking-water/revised-lead-and-copper-rule
9. https://www.epa.gov/ground-water-and-drinking-water/funding-lead-service-line-replacement
10. https://www.epa.gov/dwsrf/how-drinking-water-state-revolving-fund-works

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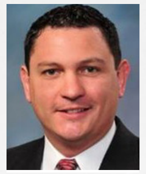


Michael Griffiths is the vice president of the Water and Community Facilities division at CoBank, a national cooperative bank serving vital industries across rural America by providing loans, leases, export financing, and other financial services in all 50 states.

How To
Reduce VOC Emissions In Wastewater Treatment

Adding to the typical worries of wastewater treatment operations, emissions from volatile organic compounds (VOCs) are the next frontier of pollution control.

By Emily Newton

Volatile organic compound emissions are why wastewater treatment must become innovative. Due to VOCs' gaseous nature, they are hard to control as they evaporate from water basins. Still, treatment facilities must take action to reduce VOCs in wastewater treatment and, therefore, the emissions.

It is vital to remove VOCs from water for the health and safety of workers, consumers, and facilities. Failure to create healthy conditions causes long-term adverse effects. Fortunately, tech innovations are helping industries overcome this obstacle to create a safer future in wastewater treatment.

The IoT Influence

The Internet of Things (IoT) is increasing the number of connected smart devices globally, providing every sector with countless ways to streamline and optimize operations.[1] IoT sensors help to gather analytics, reveal gaps in their processes, and offer improvement suggestions for remediation efficiencies. Smart water can exist among these technologies and combine with sustainable tech for an even more significant impact.

One of the best ways to treat wastewater is through activated carbon filtration, sometimes with aeration, which improves alongside smart technologies. Computers can help assess the status of the filter and how well it's working alongside various kinds of VOCs, thus providing insight into the emissions potential. Imagine IoT recognizing an irregular bacterial contaminant[2] that has reduced the efficiency of processes. Discovering these issues can reduce emissions by keeping tabs on irregularities.

IoT technologies could help one of the most vulnerable points of the wastewater treatment process — storage. Advancements could help quantify previously unknown metrics, such as how many diffuse emissions are escaping in between steps of the treatment process. Are there harmful microorganisms present? IoT devices could also monitor volatile pH and ion levels[3] during electrodialysis treatment, informing operators if they missed their chance to optimally removing fluoride. Incorporating IoT electronics to help monitor treatment systems could reduce emissions by illuminating previously undiscovered oversights.

This includes saving time in analyzing the more sustainable method for treating specific VOC compounds since some respond better to varied techniques. This improves efficiency and industry knowledge by revealing opportunities for reducing emissions.

The most popular models for analyzing VOC emissions haven't been updated in many years. Plus, they can only estimate emissions based on water sampling instead of air analysis. When plants then create their own software,[4] it could lead to inaccurate data collection. Connecting plants to IoT devices could help to create a collaborative solution for emissions measurement — a gap in the market.

Reducing Harmful Emissions

The simple answer to reducing emissions is through better treatment methods. Wastewater treatment plants rely on aeration methods to reduce odor-producing substances in water. Wastewater treatment plants can simply add pure oxygen to reduce or eliminate[5] odors while reducing their VOC emissions.

Biofiltration and other activated sludge processes in wastewater treatment are highly malleable methods that work alongside other changes in the treatment approach. Creative implementation could also improve the positive environmental impact by cultivating biomass energy from this process.[6]

Another method that treatment plants can utilize to reduce VOC emissions involves reverse osmosis. These filters have a pore size that is nearly 0.0001 microns across. This filtration method can remove all organic molecules and viruses and most minerals from water.

The Human Impact

Though renewable energy and smart technology are paving the way to reduce VOCs in wastewater treatment, there are countless ways humans can change their habits daily to better water quality. After all, numerous human activities unintentionally cause a mass spread of VOCs[7] into waterways.

One example is educating and practicing the correct disposal of products. Everyday household items containing VOCs include paints, oils, pesticides, and inks. When people carelessly discard these items, the chemicals seep into soil and waterways, exacerbating the problem. Weather conditions like wind and rain cause the spread of VOCs from their original locations, making them a widespread concern.

Increasing awareness of the risks of VOCs will help these changes take place. It's possible many have never heard of them and do not understand that they can cause:

- Mild symptoms such as coughing, headaches, or nausea
- More severe symptoms like allergic reactions or shortness of breath
- Long-term health conditions like liver damage and some cancers.

Humans could also reduce using products emitting VOCs. One way to do this is by engaging in safer home renovations, choosing products with few or no VOCs. This includes aerosols like hairsprays and air fresheners. Consumers can opt for solid or liquid forms of these products to help curb some of the burdens on wastewater treatment.

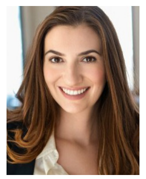
The Future Of VOC Emissions Reduction

Though the primary concern of wastewater treatment is purifying water, considering ways to purify the air is a side effect of the industry. Removing VOCs from water means higher-quality air and water, eliminating another harmful player in environmental degradation. From smart innovations to shifts in human behavior, VOC emissions in wastewater treatment could become a worry of the past. ■

References

1. https://revolutionized.com/industrial-iot-applications-for-different-industries/
2. https://www.iotforall.com/iot-changing-wastewater-management
3. https://link.springer.com/article/10.1007/s13201-021-01375-8
4. https://ufdcimages.uflib.ufl.edu/AA/00/07/95/91/00001/Splendor_Anthony_HonorsThesis.pdf
5. https://www.lindeus.com/industries/water-and-wastewater-treatment/aeration-odor-control
6. https://journals.sagepub.com/doi/full/10.1177/2516019219852603
7. https://www.usgs.gov/mission-areas/water-resources/science/volatile-organic-compounds-vocs

About The Author



Emily Newton is an industrial journalist. She regularly covers stories for the utilities and energy sectors. Emily is also editor in chief of *Revolutionized* (revolutionized.com).

MAKING POWER FROM SLUDGE: A Sustainable Solution For Wastewater Treatment

Sludge can go from a problem to a resource with energy recovery, but the process must be supported by the proper technology to truly be efficient and sustainable.

By James Chalmers

Worldwide, the volume of sludge — a byproduct of wastewater processing — has increased to over 100 million tons per year. This is driven in part by population growth and rapid urbanization, as well as broadening access to sewage systems. However, we currently only process half of the world's wastewater, meaning that 4.2 billion people still lack access to safe sanitation. As these people gain access to this essential service, the volume of sludge will continue to increase.

Sludge has historically been considered a waste product. It was once commonly given away to farms for use as fertilizer or disposed of in landfills. However, increasingly strict legislation, such as the EU Landfill Directive[1] and EPA Part 503 Biosolids Rule,[2] have stopped this.

These restrictions are increasingly common around the globe. A recent project in Mumbai, India, required the plant to meet U.S. EPA standards, for example, while South Africa has its own strict rules.

Clearly, utilities must reduce the amount of sludge they produce. One promising option is anaerobic digestion, which is already common in developed countries and newer installations in emerging economies. Installing a new digester is expensive, but facilities can use the biogas it produces as a source of heat and electricity, reducing a plant's operating costs and contributing to its sustainability.

Processing Sludge Efficiently

Sludge treatment involves several energy-intensive steps. It is screened and de-gritted to remove debris and then thickened and dewatered, traditionally using drying beds. More modern approaches used to speed up the process and treat greater quantities, such as in centrifuges or belt filter presses, are being adopted.

The sludge then undergoes thermal hydrolysis. This improves the biodegradability and viscosity of the sludge, as well as the biogas yield. It is now ready for digestion. To optimize this process, the sludge is heated to an optimal temperature for bacteria to carry out anaerobic digestion.

Anaerobic digestion reduces the amount of material and produces biogas, which consists mostly of methane and carbon dioxide mixed with other gases. The biogas is collected and purified, and then used in a combined heat and power (CHP) system within the treatment plant. Biogas can also be further refined into biomethane and sold as an additional source of revenue.

Biogas has already proven itself as a sustainable, cost-effective, and renewable energy source for generating electricity and heat, and as a fuel for transportation. As the price of electricity rises, there is an even bigger reason to invest in infrastructure to generate and capture biogas.

In many cases, electricity from biogas can produce upwards of 50% of a plant's energy consumption. However, this requires the plant to complete every processing step as efficiently as possible.

The Role Of Advanced Motors, Drives, And PLCs

Processing sludge and using it for energy involves a range of motor-driven equipment, such as pumps, agitators, centrifuges, belt presses, and mixers. Ensuring that the correct equipment is specified is essential to maximizing efficiency and keeping costs down. Fortunately, modern motors, drives, and programmable logic controllers (PLCs) achieve the high level of efficiency and precise control needed for effective sludge treatment and energy conversion.

Electric motors are key to every step of wastewater processing. They must be designed to withstand the harsh, corrosive environment of wastewater treatment facilities. However, older motors are very inefficient. Upgrading to a newer, more efficient motor can significantly reduce the energy input required to process sludge into biogas, increasing the net energy output.

In applications that do not require constant full-speed operations, further efficiency can be achieved by pairing motors with variable speed drives (VSDs), also known as variable frequency drives (VFDs), or simply drives. A drive controls a motor's speed and torque to match the requirements of the task. Any time the motor is not at full speed, it saves power. Because of the nonlinear relationship between speed and power consumption, slowing a motor by just 20% cuts its energy use by 50%. The most energy efficient class of motors, IE5, uses synchronous reluctance motors (SynRM) paired with a drive to minimize energy losses.

Drives also offer advantages in terms of precise control. Operators can use drives to adjust variables such as flow rate and mixing intensity to reduce energy consumption and extend the lifespan of equipment.

PLCs can be added to a system to automate it. PLCs can monitor variables such as temperature, pH, and dissolved oxygen levels and adjust processes accordingly. In digester applications, PLCs maintain the ideal conditions so the bacteria responsible for breaking down the organic matter can operate optimally.

The Top Priority: Safety

Drives and PLCs are also essential for safety. Modern drives include built-in functional safety features such as safe torque off (STO). This can reduce the number of injuries and accidents caused by equipment like belt presses. PLCs can also be used to detect and respond to equipment malfunctions, ensuring that processes run smoothly and safely.

In addition to the hazards of moving equipment in any application, biogas is highly flammable. Therefore, facilities must select matched motor-drive packages with ATEX-certified safety functions. ABB has designed ATEX motor-drive packages with SynRM motors that achieve the highest levels of safety, efficiency, and performance.

Giving Back To The Grid — Biogas In Action

The operators of a water treatment plant in Bocholt, Germany, aimed to reduce its environmental impact. They selected the latest SynRM motors for their sludge pumping station, which greatly reduced the amount of energy required.

They also used efficient motor-driven centrifuges to rapidly dewater the sludge before pumping it into two digesters. The biogas produced by these digesters — combined with the site's biomass, wind turbines, and photovoltaic panels — generates approximately 6.3 million kilowatt hours of electricity per year. The plant only consumes around 3.3 million kilowatt hours, so it sells the surplus to the local grid.

Elsewhere in Germany, in Trier, utility company Stadtwerke Trier has used biogas to operate a carbon-neutral facility for more than five years. It uses gas from two cogeneration plants to generate approximately 2.7 million kWh of power annually. However, this sophisticated system faced issues with "network impurities" from electrical harmonics that arose during switching. Harmonics can cause damage to equipment, shorten its lifespan, and cause power outages, among other issues.

Fortunately, the Trier facility was able to identify the source of the issue — ultrasonic wave generators — and installed active filters. When the facility added a dewatering facility in 2021, to enable storage of dried sludge for use in the cold winter months, operators selected 12 ABB ultra-low harmonic ACQ580 water and wastewater drives. These drives reduce harmonic content to a negligible level while improving energy efficiency.

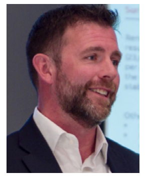
Finding Sludge's True Value

Given the immense potential of sludge, it is surprising that it was ever given away. With appropriate equipment and safety measures in place, sludge can be harnessed to produce sustainable heating and electricity, significantly cutting down on a plant's operating expenses and environmental footprint. ■

References

1. https://eur-lex.europa.eu/EN/legal-content/summary/landfill-of-waste.html
2. https://www.epa.gov/biosolids/biosolids-laws-and-regulations

About The Author



James Chalmers is vice president, global water and wastewater sales for ABB Drive Products (https://new.abb.com/drives/segments/water-and-wastewater).

Mitigating Water Concerns With A Target-Setting Framework

The Science Based Targets Network (SBTN) recently launched its new freshwater method, developed in collaboration with sustainability consulting firm Quantis to help companies reduce their impact on water systems and build long-term resilience to climate change.

By Simon Gillet

Demand for water is increasing while supply is decreasing. Reservoirs such as Lake Mead, the largest reservoir in the U.S., are drying up at alarming rates. A diminishing water supply is not only a substantial source of operational and supply chain disruption for American businesses, but it also leads to increased costs. The average price of water increased by 60% in the 30 largest U.S. cities between 2010 and 2019.

Water scarcity has caused many power station shutdowns, including a major California hydroelectric power plant that was forced to shut down for the first time since it opened in 1967. Low water levels are also disrupting major shipping routes, and cities nationwide are tightening regulations and announcing water restrictions.

These disruptions have an economic cost, and the financial losses linked to water challenges are substantial. Shipping jams caused by low Mississippi River water levels were estimated to cost $20 billion. In 2018, global companies suffered $38.5 billion in water-related losses. In 2022, depleted and contaminated water supplies led to $13.5 billion of stranded assets across four major industries (oil and gas, electric utilities, coal, and metals and mining).

According to a recent research note published by analysts at Barclays, the consumer staples sector is most vulnerable to water risk and faces a $200 billion impact from water scarcity. This is largely linked to the sector's dependence on agricultural commodities, which are highly vulnerable to fluctuations in the price of water and disruptions from droughts and flooding.

SBTN Guidance

The Science Based Targets Network has laid out a five-step process that companies can follow to supplement their current strategy for addressing environmental issues or to begin exploring for the first time. The first version of the freshwater guidance covers the first three steps (assess; interpret and prioritize; and measure, set, and disclose) in SBTN's five-step target-setting framework. The five steps are:

1. Assess
   - Screen for material issues
   - Estimate pressures
2. Interpret and prioritize
   - Determine target boundaries
   - Interpret and rank
   - Prioritize
   - Evaluate feasibility and strategic interest
3. Measure, set, and disclose
   - Measure baseline
   - Develop monitoring plan
   - Disclose baseline
   - Set targets
4. Act
   - Avoid impacts from happening in the first place
   - Reduce impacts
   - Restore ecosystems and regenerate ecological productivity
   - Transform by taking actions that contribute to system-wide change and alter the drivers of nature loss
5. Track
   - Monitor
   - Report
   - Verify

This freshwater methodology will enable companies to address quantity and quality, specifically surface water flows, groundwater levels, and nutrient pollution (nitrogen and phosphorus). At this stage, targets can only be set for a company's operations and upstream value chain. Downstream guidance is currently being developed and will be available in the future.

Protect Your Water Supply

Companies that begin to develop strategies sooner rather than later will be better resourced to respond, adapt, and protect business interests.

Companies can't manage what they don't measure, so assessing and estimating value-chain-wide impacts and dependencies on water are the first place to start. They must conduct comprehensive water footprint and risk assessments using established tools to gather data and develop a list of potential issue areas and locations for target setting. SBTN offers extensive guidance to support corporate assessments. Companies can encourage and facilitate suppliers to conduct assessments of their own water usage and impacts.

Tools available to support companies in their water assessment include:

- World Wildlife Fund's water risk filter is a screening tool to help companies and investors prioritize action on where it matters most to address water risk.
- Aqueduct was developed by the World Resources Institute to identify and evaluate water risks around the world.
- The water risk monetizer helps companies assess water-related business risks to understand the gap between what your business pays for water and the potential costs of water risks to your business.

Data from assessments can help businesses inform their strategic planning. Companies can set ambitious science-based targets using established water-related frameworks such as the science-based targets for water methodology by SBTN, enterprise water targets, and volumetric water benefit accounting. Companies can align their ambitions with what is necessary, set them for the near-term, set key performance indicators to measure progress, and prepare to disclose data.

Finally, companies must transform their internal mindset to align with their targets. In collaboration with key stakeholders such as investors, customers, sites, suppliers, and communities, businesses will need to develop clear water action plans to direct decision-making to support their set targets. Companies can innovate and consider deploying new business models, operational initiatives, and location-relevant strategies to reduce water use and pollution. They need to implement water stewardship programs that will benefit the communities they operate in to ensure continued sustainability and relationships. Implementing annual reporting on their progress and reporting publicly can maximize the potential of the collective effort. ■

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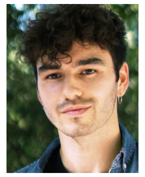
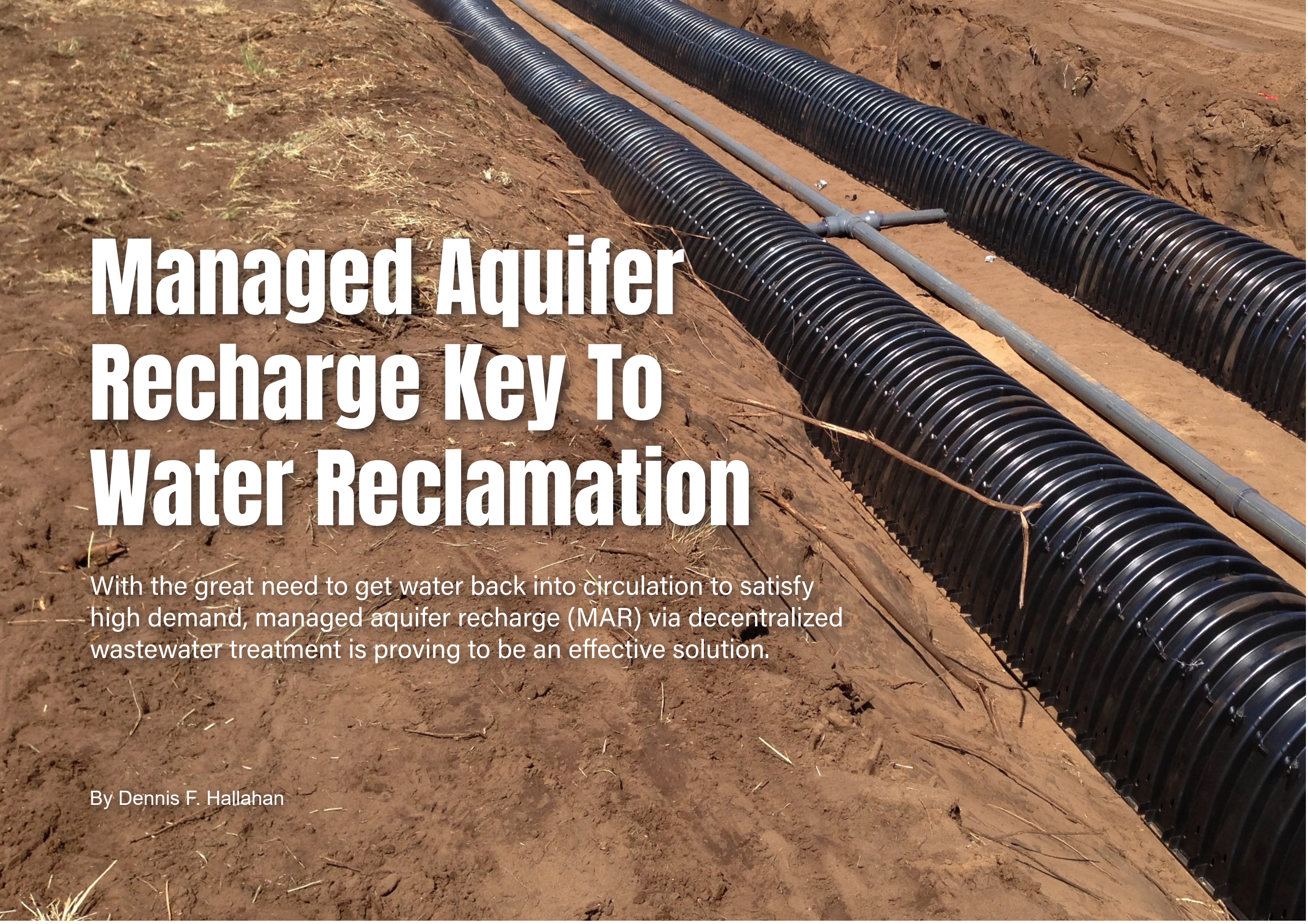


Simon Gillet is a senior sustainability expert and SBTN advisor at Quantis, which partners with leading organizations to drive sustainable transformation to operate within planetary boundaries.

References

1. https://www.cnbc.com/2021/06/29/water-scarcity-why-some-of-the-worlds-biggest-companies-are-worried.html
2. https://www.cnn.com/2021/08/06/us/lake-oroville-water-level-power-plant/index.html
3. https://www.bloomberg.com/graphics/2022-mississippi-river-drought-global-impact/#xj4y7vzkg
4. https://cdn.cdp.net/cdp-production/cms/reports/documents/000/004/232/original/CDP_Global_Water_Report_2018.pdf?1554392583
5. https://www.cdp.net/en/articles/media/financial-institutions-deeply-exposed-to-stranded-assets-caused-by-global-water-crisis
6. https://www.cnbc.com/2021/06/29/water-scarcity-why-some-of-the-worlds-biggest-companies-are-worried.html
7. https://sciencebasedtargets.org/about-us/sbtn
8. https://sciencebasedtargetsnetwork.org/how-it-works/assess/
9. https://sciencebasedtargetsnetwork.org/how-it-works/prioritize/
10. https://sciencebasedtargetsnetwork.org/how-it-works/set-targets/
11. https://waterriskfilter.org/
12. https://www.wri.org/aqueduct
13. https://waterriskmonetizer.com/
14. https://sciencebasedtargetsnetwork.org/wp-content/uploads/2020/11/Science-Based-Targets-for-Nature-Initial-Guidance-for-Business.pdf
15. https://www.wri.org/research/volumetric-water-benefit-accounting-vwba-method-implementing-and-valuing-water-stewardship



Managed Aquifer Recharge Key To Water Reclamation

With the great need to get water back into circulation to satisfy high demand, managed aquifer recharge (MAR) via decentralized wastewater treatment is proving to be an effective solution.

By Dennis F. Hallahan

Water is one of our most precious and important resources to sustain life. In some areas of the world, the dwindling supply is becoming so apparent that federal, state, and local municipalities are seeking unique solutions to ensure residents have access to clean water.

The American West is a good example, where high demand for water from the population and agriculture combined with years of drought have stressed water supplies. The Colorado River serves more than 40 million people in seven U.S. states plus two states in Mexico, but given the demand and ongoing drought conditions, this situation has resulted in an increasing focus upon groundwater. In California, wells are drying up in record numbers, leading to an unprecedented surge in new deep well drilling permits. The significant drop in groundwater elevations has threatened land subsidence and resulted in saltwater intrusion.

> **Managed aquifer recharge (MAR) is intentionally recharging aquifers for a future recovery and/or other benefits.**

While the American West is in the spotlight, water scarcity has also hit the wetter regions of the U.S. as the Eastern states also face many water supply and quality problems. Water utility managers have stated, "Cheap water is gone."

There is a variety of ways to reclaim or reuse water to sustain supply. Solutions to reclaim water include utilizing recycled wastewater through purple pipes, reuse for nonpotable use, desalination, indirect potable reuse, sewer mining, or direct potable reuse. These methods can come with significant costs and often are unpopular with the public. While there's no clear-cut solution that makes sense for water reclamation in every area of need, one of the methods growing in popularity is managed aquifer recharge as an indirect potable reuse solution.

What Is Managed Aquifer Recharge?

Managed aquifer recharge (MAR) is intentionally recharging aquifers for a future recovery and/or other benefits. There are many methods to provide MAR, including but not limited to aquifer storage, rapid infiltration basins, subsurface discharge systems, and deep well injection. Existing water supplies such as wastewater discharges or even rivers can be identified as sources to recharge aquifers. During periods of high river flows from snow melt, portions of the flow can be diverted and redirected to provide MAR. These sources of water that would otherwise drain out to the sea and be lost can be reused, and become invaluable to sustaining humans, wildlife, flora, and crop production. The MAR approach is gaining popularity in water-distressed communities and coastal areas where saltwater intrusion is a threat.

> **It's possible to take 1-MGD treatment systems and successfully implement a recharge system when proper site conditions exist.**

MAR Accomplished Through Decentralized Wastewater Treatment

The ability to recharge groundwater and replenish aquifers is a noted environmental benefit of decentralized wastewater treatment systems according to the U.S. EPA, making decentralized wastewater treatment systems one of the most effective MAR methods.

Decentralized wastewater treatment systems locally treat and disperse water, completing the water cycle in a small footprint with very little energy. Centralized wastewater treatment systems require massive investments in infrastructure.

In a typical decentralized wastewater treatment system, wastewater exits the home to the septic tank, where primary treatment occurs before discharge into a drainfield/leachfield/soakaway. Further treatment occurs within the soil until it returns to the groundwater, thereby recharging the local aquifer and achieving MAR.

In the centralized scenario, water is extracted from a source, treated to potable standards, then pumped via a pipe distribution network to its use destination. Once this water is used by a facility or homeowner, it is classified as wastewater and ultimately discharged, following centralized treatment, to a river or ocean. In the centralized approach, the disposal of the treated wastewater commonly occurs in local waterways, where it mixes with the existing water flows and is never captured for reuse.

How Much Water Is Recycled Through Decentralized Wastewater Treatment Systems?

Approximately 25% of the population in the U.S. relies on an individual onsite wastewater treatment system to treat used household water. Based on design standards, that estimates out to 18,000 gallons per person per year. Multiply that by the current U.S. population of 83 million people who are served by onsite wastewater treatment, and it is roughly 1.5 trillion gallons per year of water passively recycled through onsite wastewater treatment systems. Of note is that this flow rate only includes single-family systems and there are commercial facilities served. The extensive advancements in decentralized technology and design have enhanced the capability of decentralized wastewater treatment systems to treat large volumes of water for commercial facilities or cluster systems and still discharge to the subsurface. Today, there are decentralized MAR systems that have discharges in excess of 1 MGD.

Examples Of Wastewater Treatment And MAR

It's possible to take 1-MGD (3,785 cubic meters per day) treatment systems and successfully implement a recharge system when proper site conditions exist. Good, percolating soils and a dedicated land area are necessary for the recharge fields. Here are a few examples.

Chamber beds installed to receive highly treated waste that will infiltrate and resupply the local aquifer

Los Osos, CA

The coastal community of Los Osos, CA, needed to address wastewater issues created by outdated systems and a history of nitrogen issues and saltwater intrusion. Exacerbating the challenge, the small lots within the community were not large enough to construct code-compliant single-family septic systems. In 2013, a community wastewater treatment system was designed and installed that would treat a design flow of 1.6 MGD (6,060 m³/d) and recharge the local aquifer. From the community wastewater treatment plant (WWTP), the treated effluent is pumped to a large chamber dispersal field that was installed along a hillside with ideal soils to facilitate aquifer recharge. With this solution, the

Decentralized systems naturally recharge local aquifers, and these infiltration systems can be sized to accommodate much larger flows.

town-owned property was converted to open-space walking trails and preserved for the community; therefore, the land was still functional while providing active recharge to the local aquifer.

Gold Beach, OR

The town of Gold Beach, OR, had an existing centralized wastewater treatment system that was experiencing infiltration and inflow (I&I) problems. This resulted in the wastewater plant overflowing, carrying over solids, and then plugging and overflowing of the existing recharge system. The town implemented an I&I repair program and replaced and expanded the recharge fields. The design flow of the existing WWTP was 2 MGD (7,570 m^3/d) and the recharge system was expanded from nine beds to 21 with three separate zones, each with seven beds. Each zone is served by its own pump, which allows for O&M flexibility and redundancy. The chamber beds were installed in the coastal plain area between the treatment plant and the ocean along the sides of a small airport. There were even design considerations in place to address the strength of the system if an airplane ran off the runway and over one of the beds. The MAR system will provide a much-needed barrier to saltwater intrusion.

Gillette Stadium – Foxborough, MA

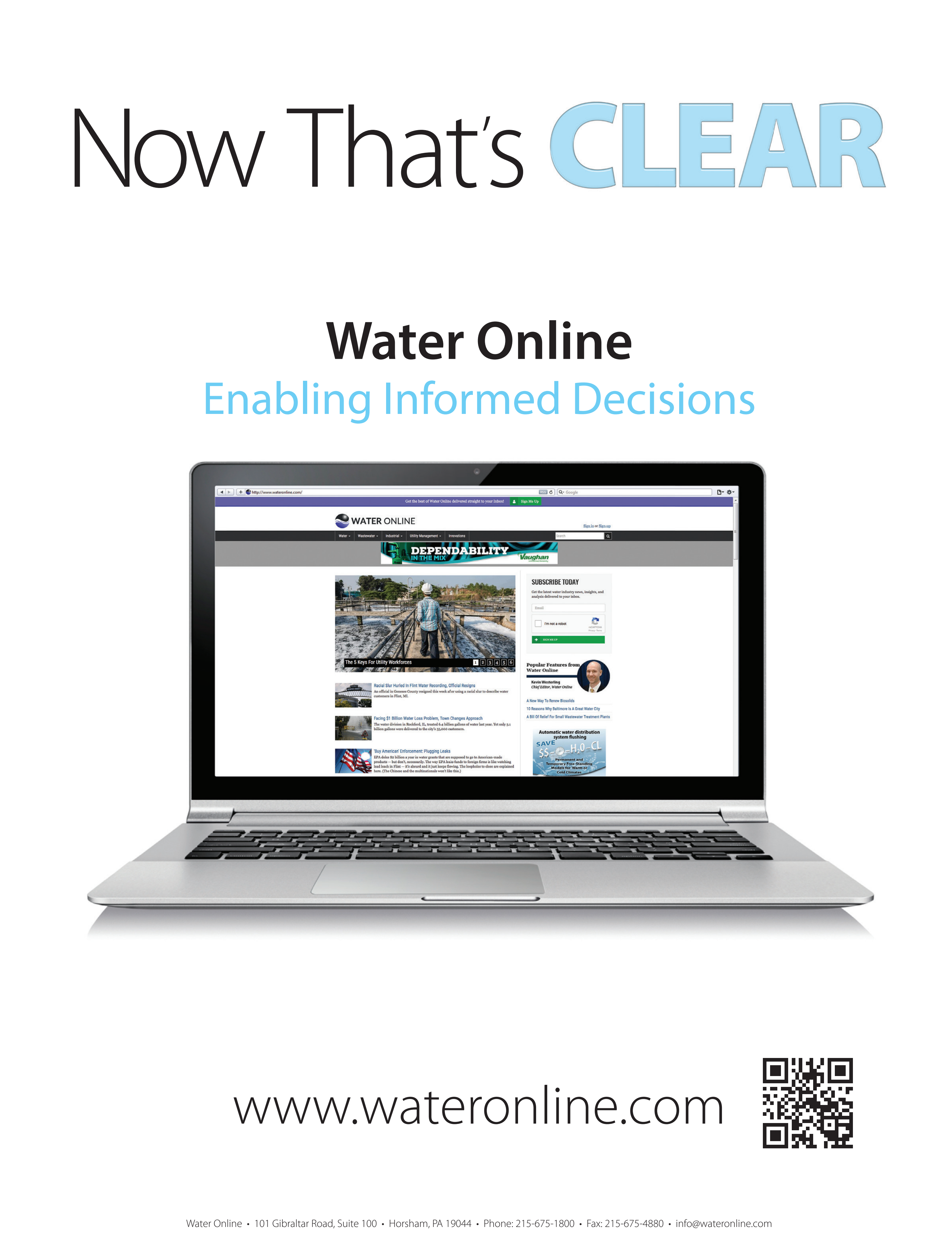
When the new Gillette Stadium was constructed in 2000, the wastewater treatment system was required to be upgraded according to current state codes. A WWTP was designed for 250,000 GPD (945 m^3/d) following a 680,000-gallon (2,575 m^3) flow equalization tank to accommodate the 1 MGD (3,785 m^3/d) design flow from the stadium during events. The membrane bioreactor (MBR) treats the wastewater to a level acceptable for reuse for toilet flushing. The wastewater is then returned to the stadium for reuse when needed or discharged to the subsurface disposal chamber beds installed below the parking lots surrounding the stadium for groundwater recharge.

Conclusion

According to the World Economic Forum, water scarcity is one of the greatest challenges of our time, and it will take many approaches to solve the supply and demand needs of future generations. Ongoing drought, high water usage from growing agricultural needs, and population increases will continue to stress the aquifer and groundwater supply. Effective MAR approaches and water reuse will help to combat this growing challenge. Ultimately, water conservation awareness and implementation by all water users are also needed to make a lasting positive impact. ■

About The Author

Dennis F. Hallahan, PE, is the technical director of Infiltrator Water Technologies. Dennis has over 30 years of experience with the design and construction of onsite wastewater treatment systems. He has written several articles for onsite industry magazines and has given numerous presentations nationally on the science and fundamentals of onsite wastewater treatment systems. Dennis also oversees a department that is responsible for product research and testing for universities and private consultants.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